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TITLE: SORTING DEVICE

Technical Field

The present invention concerns a sorting device and a method to sort objects within a bulk of objects, where the objects differ in quality.

The sorting device is developed for use with a method of sorting objects within a heterogeneous population by removal from the sorting device at least one collected fraction of different quality of composition with reference to one or more specific characteristics of the objects. The invention is developed for industrial use, i.e. it should be possible to handle large quantities at a high rate.

Prior Art

There exist a number of methods for coarse sorting or removing (cleaning) objects according to length, size and density.

For example, in the cleaning of grains it is common to use machines designed to screen out over- and undersized material or to classify for example malting barley according to the width of the kernels. Further gravity tables are used for coarse sorting of granular materials according to the density of the granules. However, to function well there should be a substantial difference in density between the different fractions.

It is known to sort grains by means of a rotating cylinder or drum, which cylinder has pockets on the inside. This indented cylinder is rotating (axis horizontal) and granules are feed into one end of the cylinder, and as the cylinder rotates the granules will be lifted in that they are captured in the pockets. The pockets are given a design by which ideally one single granule is to be received in each pocket. As the cylinder rotates the granules fall out

of the pockets in different positions due to the gravity. A trough is placed inside the cylinder to be able to separate the granules falling at a late position. Long granules have a point of gravity in the upper part of the pockets and fall out earlier than shorter granules, which fit in deeper into the pockets. The granules not captured in the trough leaves the cylinder as an overflow. By this device it is normally not possible to sort the granules into more than two groups, if further separation is wanted further cylinders may be placed after the first cylinder. Furthermore, the sorting is only done depending on length and/or shape. The single granules are not passed before a detector.

There are also machines, which sort/clean granular materials according to their colour. In these machines the material to be sorted/cleaned is made to fall into the free atmosphere, ideally one by one. During their fall the granules are illuminated with light. The reflected light from each granule is detected at 1-3 pre-selected bands of wavelength in the visible and/or infrared (IR) range by use of optical filters. These bands are pre-selected in order to give a signal corresponding to a known and desired sorting/cleaning characteristic of the granules. Furthermore, in these methods the optical filters are selected so that there is a substantial difference in the fraction of reflected light from a wanted versus an unwanted granule, which light will reach sensors through the filters. If a granule having unwanted characteristics is detected it will be blown to one side during the continued free fall.

One problem with colour sorters is that several granules surrounding the detected, unwanted granule will be blown to the one side together with the detected granule. Thus, the rejected granules will include a high percentage of granules that should not have been rejected. The colour sorter is only used to clean out not suitable granules present in low percentages such as impurities and discoloured

granules etc. and it is used as a cleaning device and not used to sort granules into several different fractions of more specific characteristics.

In practice the known devices often only function as a cleaning device, i.e. removing impurities, defect objects etc.

The Invention

To simplify, the expression "granule" is used in the description below as a general term. Thus, in this description "granule" should be interpreted broadly and also covering other types of products suitable for sorting, such as plastic parts, beads, pills, grains etc. The expression "object" is used in this description interchangeable with "granule", and thus should also be interpreted broadly. A person skilled in the art realizes that the exact type and form of the granules, objects etc. to be sorted are of no importance for the invention as such.

The sorting device could be divided into three main parts or rather functions that it should fulfil. These parts are a positioning means, a detecting means and an ejecting and collecting means. Furthermore, some source or sources of radiation or sonic waves are provided for co-operation with the detecting means. Each granule should first be positioned separately and in a well-defined position for passing a detecting means. Depending on the result of the detection the ejecting means will eject each granule into desired and preselected subgroups matching the detected quality or qualities. In order to be able to fulfill the above functions in a proper way some kind of control means is arranged.

The specific qualities or characteristics to be sorted for may be the form, density, colour, etc. It may also be a variation in chemical composition, a derived property like wetability, flavour, thermal plasticity, mil-

lability or a potential of a certain class of the objects to cause good baking quality of a seed after processing, a large volume of popcorn after popping, a particular strength of a plastic object, pharamaceutical pills having no tendency to burst, a less bitter taste of chocolate after processing of cocoa beans, etc.

The device of the present invention is to be used for sorting of objects from a heterogeneous population. It provides real time ultra fast steps of: energy exposure, recording of a first signal, preprocessing of the recorded first signal, classifying and/or predicting of a second signal and ejection of each of the objects. Image analysis, radiation analysis, spectroscopic analysis, sonic wave analysis etc. may be used in connection with the sorting device of the present invention. Thus, CCD-cameras, detectors for emitted, transmitted and/or reflected light or radiation, both for multivariate and univariate detection etc. may be used for detection of the specific characteristics to be sorted for. To simplify we use the expression "detection means" in this description, which expression should be construed to cover any suitable detector including possible recording and processing equipment, e.g. the above detectors. Any electromagnetic radiation or sonic waves, alone or in combination, can be used, such as ultraviolet light, visual light, near infrared light, infrared light, fluorescent light, ultrasonic waves, microwaves, or nuclear magnetic fields.

One object of the present invention is to arrange the single granules in a bulk of granules in such a way that they can be scanned and ejected separately.

A further object of the present invention is to be able to divide the granules etc. into several subgroups due to one or more specific characteristics.

A further object of the present invention is that it shall be possible to sort a large quantity of granules or

objects at a relatively high speed. The invention is developed for use in production lines.

The sorting device is further developed to be able to sort each single granule (object) or the like independently into subgroups having similar quality regarding one or more specific characteristics important for the end results of the production chains, where the granules are used.

According to one aspect of the present invention a drum having pockets on the inside is used. The drum is rotated with such a high speed that the granules will be held by the centrifugal force in the pockets. The pockets are placed to pass a detector by which the single granules are classified. The granule is then ejected by force to a receiving means normally placed inside the drum. Several receiving means, one for each preselected sub-group, are placed inside the drum and each granule is ejected into the receiving means matching the detected specific characteristics.

The granules are separated in such a way that they are led one by one past the detector and following that to the ejectors. Thus, there is a distance between the single granules during the detection and ejection steps.

The previously known devices often has a more or less passive ejection, e.g. the objects fall out of pockets due to size. In the present invention the ejection is active, i.e. the ejection is done by an active action.

Further objects and advantages with the present invention will be obvious for a person skilled in the art when reading the detailed description below of at present preferred embodiments.

Brief Description of the Drawings

The invention will be described more closely below with reference to preferred embodiments, by way of example, and with reference to the drawings below. In the drawings,

Fig. 1 is an end sectional view of an example of a sorting device according to the present invention;

Fig. 2 is a perspective view of a part of the sorting device of Fig. 1;

Fig. 3 is a detail view of a part of the sorting device of fig. 1;

Fig. 4 is a view exemplifying different placing of the detectors and co-operating energy sources;

Fig. 5 is a view exemplifying different arrangements for the detectors and co-operating energy sources;

Fig. 6 is a view exemplifying different placing of the ejectors;

Fig. 7 is a principal view of one way to operate a sorting device according to the present invention; and

Fig. 8 is a block diagram of an alternative way to operate the sorting device.

Detailed Description of Preferred Embodiments

The apparatus of the present invention comprises a drum or cylinder 1 in which the granules 9 to be sorted are received. The cylinder 1 may have any orientation in use, i.e. the rotational axis may be vertical, horizontal or show any angle between vertical and horizontal. The inside 2 of the cylinder is furnished with a large number of pockets 3. In the shown embodiment the pockets 3 have a rounded form both in a vertical and a horizontal plane. In other embodiments the pockets 3 have other shapes, depending on the form of the objects or granules 9 to be sorted. One granule 9 is to be received inside every pocket 3. The form of the pockets 3 is adapted to the granules 9 to be sorted. For different types of granules 9 differently shaped pockets 3 will function best. It is also possible to have a pre-sorting of the granules 9 according to size and shape to be able to have a more precis design of the pockets 3.

The cylinder 1 is received in some kind of stand 11 as indicated in Fig. 1. However, as the exact form of the stand 11 is of no importance for the present invention it will not be discussed further here.

In use the cylinder 1 is rotated with at least such a high speed that the granules 9 will be held in the pockets 3 by means of the centrifugal force. However, the cylinder 1 should not be rotated with a too high speed, as that may lead to a higher risk of overfilling, e.g. more than one granule 9 in each pocket, and that it may be more difficult to get a proper ejection. The cylinder 1 rotates with approx. 3 mm/ms in one embodiment. Thus, the equipment must be "quick" enough to detect and sort at such speeds.

The pockets 3 are normally placed in a number of rows inside the cylinder 1, with only a short distance between adjacent rows of pockets 3. Also the pockets 3 of each row are normally placed at a short distance from each other. In some embodiments the distance between the separate pockets is relatively large to get a more well defined filling. Each row of pockets 3 is extended in the circumferential direction of the cylinder 1. The number of rows varies but is often between 20 and 200. However, the number of rows is of no importance for the principals of this invention. The number of rows and the number of pockets 3 per row are dictated by a number of factors such as the size, quantity and filling performance of objects 9 to be sorted, the number of detectors, energy sources and ejecting means used, available space, desired capacity etc.

The cylinder 1 functions as a positioning means used to present the objects 9 in separated and well-defined positions. A person skilled in the art realizes that any apparatus capable of this at a high speed may be used as positioning means. Thus, as used in this description the term "positioning means" covers any such apparatus.

In alternative embodiments (not shown) concentric rings with pockets or rings forming concentric rows are used as positioning means.

In the bottom of each pocket 3 an opening 4 is normally provided. The bottom of each pocket 3 is formed in order for the granules 9 to be placed securely over the openings 4. Due to the design of the bottom and the centrifugal force induced by the high rotating speed of the cylinder 1 each granule 9 will take the desired position covering the opening 4. Furthermore, the center of gravity of each granule 9 is normally such that the granules 9 are oriented in a similar fashion in the pockets 3, if the center of gravity is not equal to the geometric center.

Both one detector (sensor) 5 with related energy source 10 and at least two ejectors 6 are connected to each row of pockets 3 in position to normally be able to communicate with the opening 4 of each pocket 3. The opening 4 of each pocket 3 may be elongated to give an extended detection area/period. The distance between detector 5 and ejector(s) 6 is such that the detection and subsequent calculation is completed when the granule 9 is in position for ejection.

In order for the granules 9 to have a well-defined position during detection and ejection a timer is often used. By means of the timer the exact position of each pocket 3 is established and correlated (synchronized) to the positions of the detecting means 5 and the ejecting means 6. In stead of all the time controlling the position of each pocket 3 during detection and ejection, in another embodiment one presumes that there is a sufficently exact distance between adjacent pockets 3. In the latter case the position of the pockets 3 in relation to the detecting means 5 and ejecting means 6 may be checked regularly, e.g. once every turn of the cylinder 1 or at fixed time intervals.

Normally one detector 5 is arranged to take care of several rows, by means of fiber optic cables 12 or the like. To give a larger measuring area a lens may be placed at the end of each fiber optic cable 12. As used in this description the expression "detecting means" includes a detector and possible fiber optic cables, lenses, filters etc. A person skilled in the art realizes that the principals of the invention are the same, whether only a detector 5 alone or a detector 5 combined with fiber optic cables 12 and possible lenses, filters etc. are used. The pockets 3 in adjacent rows may be displaced somewhat so that the detector 5 will be able to operate on one row at the time. At least one energy source 10 is provided to expose the objects 9 in the pockets 3 to emitted energy. The energy emitted may be electromagnetic radiation and/or sonic waves, distributed directly to the object or via fiber optic cables, lenses, diffusers, filters etc. The energy source(s) emits energy, which by reflection, transmission or emission from the objects are received by the detector(s) 5. In an alternative embodiment (not shown) photocells with or without filters are used as detection means. Depending on the magnitude of the received signal, often in view of a reference signal, the proper ejection means is activated to eject the object 9 into the proper receiving means 7.

A reference signal may be taken up by a parallel detection means receiving the signal directly, thus without having passed, being emitted or having reflected on an object 9. In order for the further photocell to receive the reference signal the cylinder 1 may be furnished with openings. The positions of these openings are correlated to the calculated positions of the detection means and pockets 3 during detection.

As indicated in Figs. 4 and 5 the detectors 5 and cooperating energy sources 10 may be placed in different po-

sitions and may each cover several rows of pockets 3. The detectors 5 and energy sources 10 may be placed on the same side or on opposite sides of the object 9 in the pocket 3. Furthermore, both each detector 5 and each energy source 10 may be utilized for one or several rows of pockets 3, e.g. by means of fiber optic cables 12. If both the detector 5 and the energy source 10 are placed on the same side of the pocket 3, the pockets 3 may not have any opening (see Fig. 4D). However, an opening 4 may be needed for the ejection means.

The ejecting means 6 will normally give a short air - pulse to blow each granule 9 directly or through an air pipe into a proper receiving device 7. A suitable source of compressed air (not shown) is connected to the ejecting means 6, by means of a valve. The valve may be single way or multi way. By means of the multi way valve the air pulse of the air source may be led to several ejectors 6, thus ejecting several objects 9 simultaneously. The valve is opened when the ejecting means 6 is to eject an object. A person skilled in the art realizes that any type of ejecting means may be used. In one embodiment the ejecting means 6 operates at a frequency of 150 Hz (pulses/second). If the frequency of the ejecting means is too low to have enough time for the appropriate number of ejections, two ejecting means 6 may be arranged operating alternately. The ejecting means 6 are normally placed outside the cylinder 1. However, in some embodiments the ejecting means 6 are placed on the inside, at an angle to the pockets 3 (see Fig. 6B). In the latter case the pockets 3 may be closed, if not the detection means 5 require an opening 4 at the bottom of the pocket 3.

As used in this description the term "ejecting means" covers any type of ejecting means capable of ejecting the granules or objects at the proper position. The term "ejector" is mainly used in this description for a nozzle, jet,

tube, pipe etc. used for directing an air pulse towards the objects.

An appropriate number of ejecting means 6 are placed in connection with each row of pockets 3. At least one ejecting means 6 is placed in connection with each receiving device 7 in a position to be able to eject a granule 9 into that receiving device 7. Put in other words at least one ejecting means 6 is arranged for each subgroup. Often the last ejecting means 6 has no valve and is open all the time, thus giving a constant airflow. In this way the pockets 3 are always emptied. In some embodiments it is enough that the ejecting means 6 just force the granules 9 out of the separate pockets 3. The granules will then fall by means of gravity into the proper receiving device 7. In such a case the positions of the ejecting means 6 have to be adapted to the positions of the receiving devices 7.

As stated above the detectors 5, ejecting means 6 and energy sources 10 are placed either on the inside or the outside of the cylinder 1.

In connection with the ejecting means 6 two or more receiving devices 7 are placed. The receiving devices 7 are normally placed inside the cylinder 1. The receiving devices 7 are to receive the sorted granules 9 and lead them to a receptacle (container) 8. The number of receiving devices 7 and receptacles 8 used are due to the number of fractions or subgroups that are to be produced. Normally there is a receptacle 8 for each granule 9 having one or more qualities within certain intervals. There may also be receptacles 8 for granules 9 having qualities above and under, respectively the useful intervals.

In one embodiment the receiving devices 7 are troughs 13 placed inside the cylinder 1. One trough 13 is arranged to receive each separate sorted fraction. The granules 9 are led from the troughs 13 in a suitable way, e.g. by means of a conveyor screw placed in the bottom of each

trough 13. Any suitable receiving devices 7 may be used such as tubes leading to receptacles 8 etc.

In a further embodiment (not shown), the granules 9 are released directly to the outside of the cylinder 1 from the pockets 3. This is done in that the bottom of each pocket 3 has the form of an openable flap or the like. If several concentric rings are used as positioning means the ejection may be arranged in that two adjacent rings move slightly away from each other, releasing the proper object.

The detectors 5, ejector 6, energy sources 10 and/or receiving means 7 are controlled by some kind of controlling device. The controlling device is adapted to the type of objects and the sorting to be performed.

In the exemplified embodiment of Fig. 7 a micro controller unit (MCU) is used to control the detectors 5 and ejector 6. An A/D converter is arranged to convert the first signal from the detector(s) 5 from an analogue to a digital signal. The digital signal enters the MCU. In the MCU, the first signal may be transformed by means of a supervised or an unsupervised pre-treatment. The pre-treated first signal is by means of a calibration model previously performed converted into a second signal expressing the magnitude of the specific quality(ies) to be sorted for. The first signal can be multivariate or univariate in its nature. The magnitude of the second signal is used for classification of the objects into different subgroups. The calibration model is stored on an EEPROM included in the MCU. Different calibrations are used for different types of objects and/or different specific characteristics to be sorted for. The same MCU may be used, but with adapted software. In one embodiment the adaptation of the software is done remotely, e.g. via the internet, an intranet etc.

The number of subgroups and the magnitude range of the second signal in each of the subgroups are set before sorting. Assume that one want to sort into three subgroups

(A, B and C) as exemplified in Fig. 7. Then when the second signal is within the limits of subgroup A, a signal is sent from the MCU to activate the corresponding ejecting means 6, and when the second signal is within the limit of subgroup B, a signal is sent from the MCU to activate the corresponding ejecting means 6 and so on.

The sorting process is controlled by the processor in the MCU according to the timing logic and when applicable adequate timing signal(s).

In Fig. 8 a principal way to control the sorting device of the present invention according to one aspect is indicated in a block diagram. When the timer(s) or timing logic(s) detects a granule 9 in proper position, it activates the sensor 5, with a time delay. The signal from the sensor 5 is processed in the classifier to establish into which receptacle 8 the granule 9 should be ejected. Then the ejector logic activates the appropriate ejecting means 6 at the right time, controlled by the timing logic. Thus, the granule 9 is fed into the receiving means 7 corresponding to the specific quality(ies) of the granule 9.

The function of the apparatus may be described in the following way. The granules 9 are first fed into the cylinder 1. As the cylinder 1 is rotated the granules 9 will be received in the pockets 3, one granule 9 in each pocket 3. The form of the pockets 3 is adapted to the form of the granules 9 in such a way that only one granule 9 is received in each pocket 3. Furthermore, the form of the pockets 3 in co-operation with the centrifugal force make the granules 9 to be placed over the opening 4 of the pocket 3.

The proper and separate position of the granules 9 in the pockets 3 is used to secure a high precision detection and ejection, where only one granule 9 is ejected at the time, and where the granules 9 in the vicinity are not influenced, as the case in the free atmosphere falling in the colour sorter.

It could be said that the pockets 3 are used to position the granules 9 in proper or well-defined position for detection, or in other words in a proper position in view of the detector 5. With the granule 9 in the bottom of the pocket 3, the quality of the granule 9 is detected by means of the detector 5. Depending on the quality established the granule 9 is ejected into the proper receiving device 7, by means of the ejecting means 6. Via said receiving device 7 the granule 9 is transported to a receptacle 8 corresponding to the detected quality of the granule 9.

Depending on the form and type of granules 9 to be sorted a cylinder 1 having appropriate pockets 3 is chosen. The rest of the equipment may be used after adaptation of the control software. Thus, only the cylinder 1 has to be changed to perform a new sorting. It is also possible to arrange the pockets 3 on loose plates that are exchanged if needed. In other embodiments (not shown) the cylinder, concentric rings etc. is replaced by bands, belts, chain or rope arrangements, chutes etc. giving the objects a well-defined position. Thus, the term "positioning means" also covers the above. Sometimes also a counting device is arranged to count the number of sorted objects 9.

Furthermore, means are normally provided to "handle" dust and the like. Normally this is done in that the cylinder 1 is under a slight underpressure, while the detectors and energy sources may be flushed with filtered air. Sometimes the last ejecting means 6, i.e. the ejecting means 6 placed furthest from the detector 5, is constantly blowing air. Thereby, possible dust left in the pockets is blown out.

CLAIMS

1. A sorting device for sorting granules, objects or the like (9) within a bulk of such objects (9), where the objects (9) differ in quality, **characterized** in that it comprises a positioning means giving a well-defined position for each granule, object or the like (9), a detecting means, a source (10) of electromagnetic radiation or sonic waves, an ejecting means and a receiving means.

2. The sorting device of claim 1, **characterized** in that the well-defined positions for each object (9) are placed in rows.

3. The sorting device of claim 1 or 2, **characterized** in that the positioning means has pockets (3) placed in rows to position the objects (9) in the well-defined positions; and/or that centrifugal forces are used in connection to positioning and holding of the objects (9) in the well-defined positions.

4. The sorting device of any of the previous claims, **characterized** in that the positioning means is a cylinder (1) having a number of pockets (3) placed in rows along the inner circumference of the cylinder (1) and that the cylinder (1) is rotated with such a high speed that the granules or the like (9) are positioned and held in the pockets (3) by means of centrifugal force.

5. The sorting device of any of the claims 1 to 3, **characterized** in that the positioning means is concentric rings, bands, belts, chain or rope arrangements, chutes or screens.

6. The sorting device of any of the claims 2 to 5, **characterized** in that one detecting means is placed for cooperation with each row and that the detecting means is a detector (5) for emitted, transmitted and/or reflected light or radiation or sonic waves, a CCD-camera or a photocell.

7. The sorting device of claim 6, **characterized** in that one detector (5) is arranged for co-operation with several rows of pockets (3) by means of fiber optic cables (12), filters and/or that a lens is placed at the end of each fiber optic cable (12).

8. The sorting device of any of the claims 2 to 7, **characterized** in that the ejecting means are two or more ejectors (6) placed in connection with each row of pockets and for co-operation with the detecting means and that an source of compressed air is connected to at least one ejector by means of a single way valve or a multi way valve; that the ejecting means has the form of flaps opening to the outside of a cylinder (1) or the like; or that the ejecting means has the form of at least two parts of the positioning means moving away from each other.

9. The sorting device of any of the previous claims, **characterized** in that two or more receiving means (7) are placed to receive the objects (9) or the like being ejected by the ejector means (6) and/or that the receiving means (7) are troughs (13) having a conveying mechanism at the bottom leading to a receptacle.

10. The sorting device of any of the claims 3 to 9, **characterized** in that an opening (4) is furnished in the bottom of each pocket (3), which opening (4) is small enough not to let the granules or the like (9) through; and/or that each pocket (3) is adapted to the form of the granule or the like (9) and has a form in the area of the opening (4) that facilitates that the object is postioned to fully cover the opening (4).

11. The sorting device of any of the claims 3 to 10, **characterized** in that it further includes a timer, used to control the position of each pocket (3) and/or object (9) in relation to the detecting and ejecting means; and/or that the detecting means and ejecting means are connected to a micro controller unit, MCU.

12. The sorting device of claim 11, **characterized** in that an A/D converter is placed between each detecting means and the MCU and that the MCU includes at least a processor, an EEPROM and I/O units.

13. Method for sorting granules, grains etc. into different fractions, **characterized** in that the granules are separated in such a way that each single granule passes a detecting means in a well-defined position, and that the granule is ejected into a receiving means in accordance with detected properties.

14. The method of claim 13, **characterized** in that centrifugal forces are used in connection to positioning and holding of the objects (9) in the well-defined positions when passing the detecting and ejecting means.

15. The method of claim 13 or 14, **characterized** in that the granules etc. are divided into two or more subgroups depending on detected qualities of each single granule etc.

ABSTRACT

The present invention concerns a sorting device and a method to sort granules, objects or the like (9) within a bulk of objects (9), where the objects (9) differ in quality. The sorting device comprises a positioning means (1) giving a well-defined position for each object (9). A detecting means (5) is arranged to receive electromagnetic radiation or sonic waves sent by an energy source (10) via the objects (9). Furthermore, ejecting means (6) are arranged to eject the objects (9) into a receiving means (7) based on the detected quality.

To be published with Fig. 7.

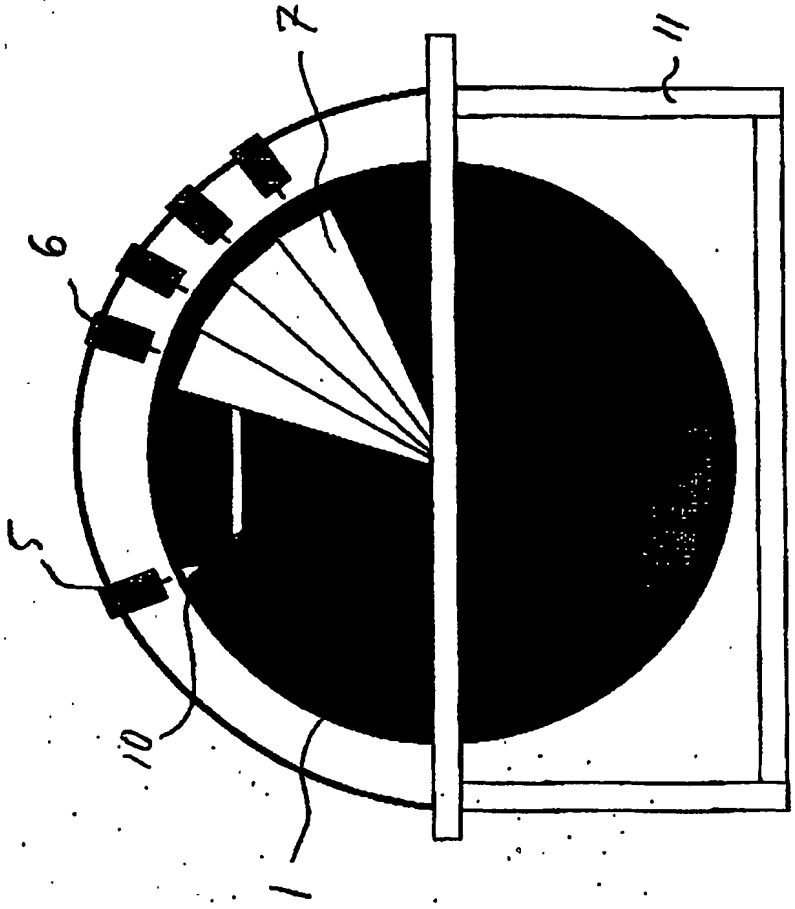


Fig. 1

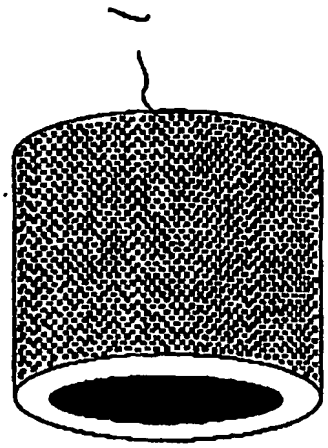


Fig. 2

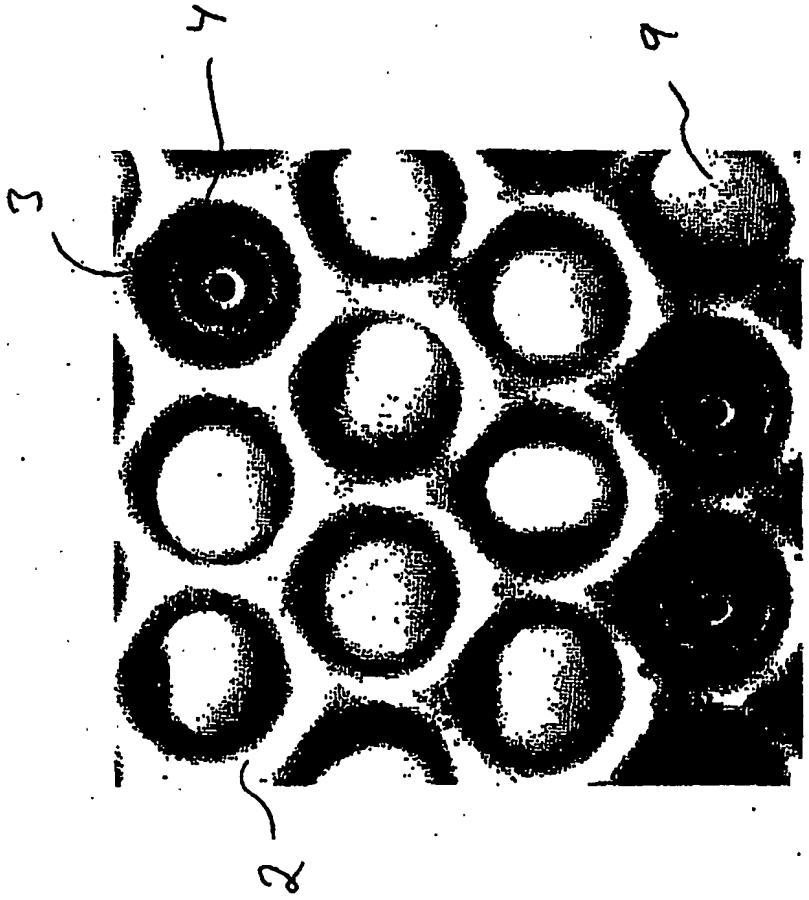
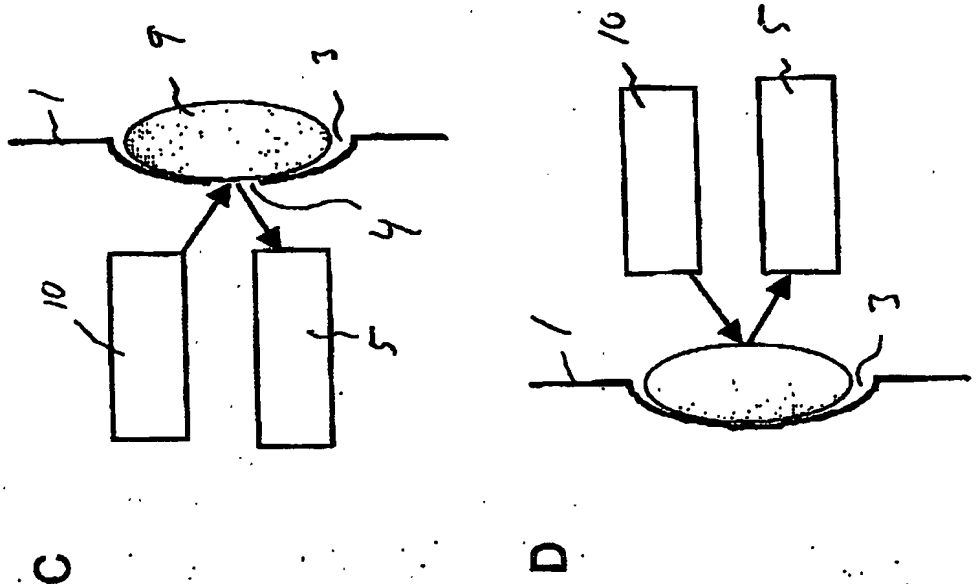


Fig. 3



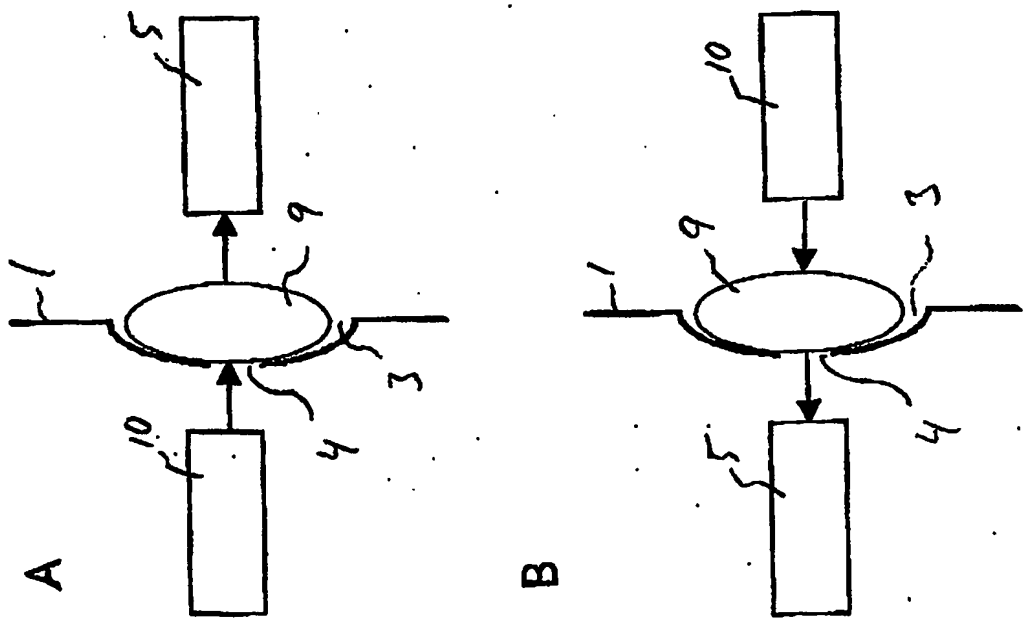


Fig. 4

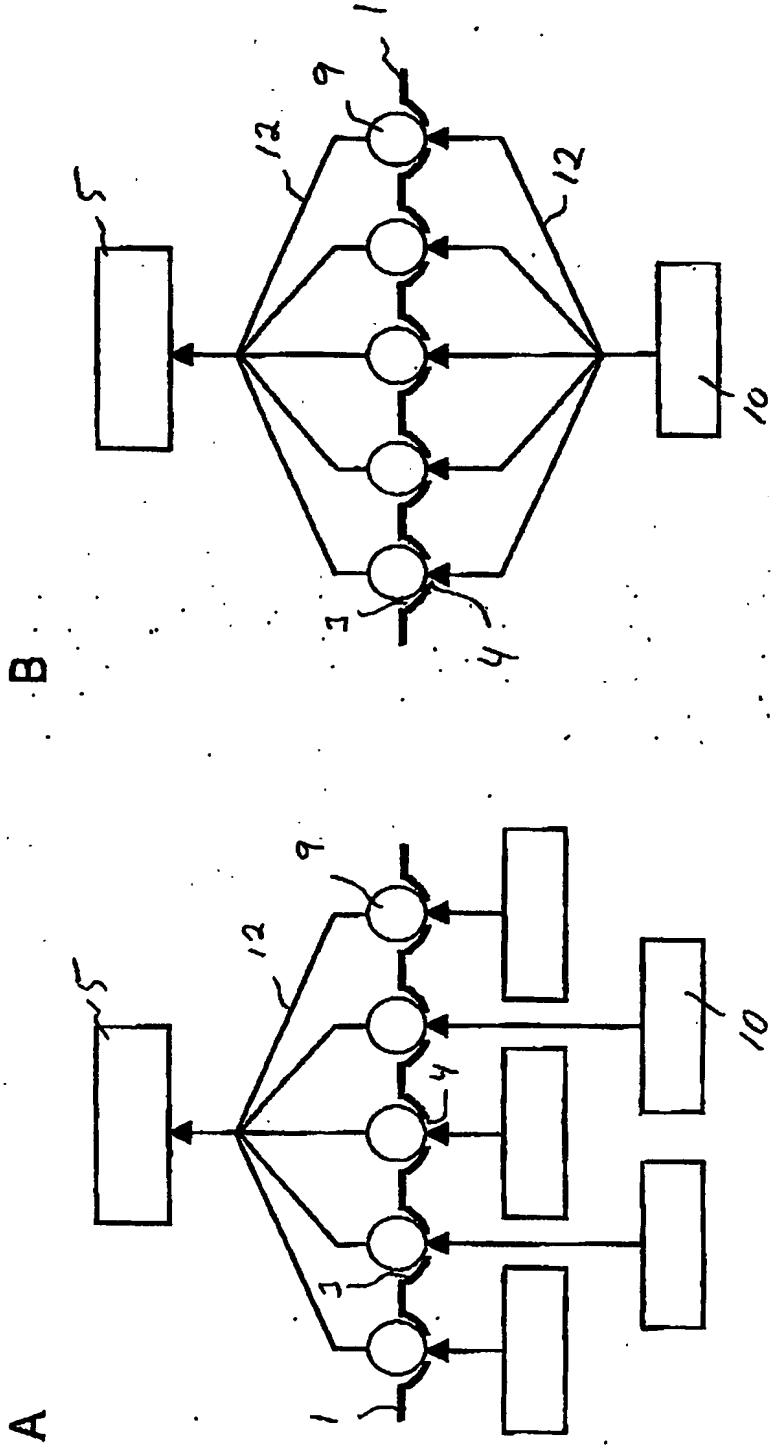
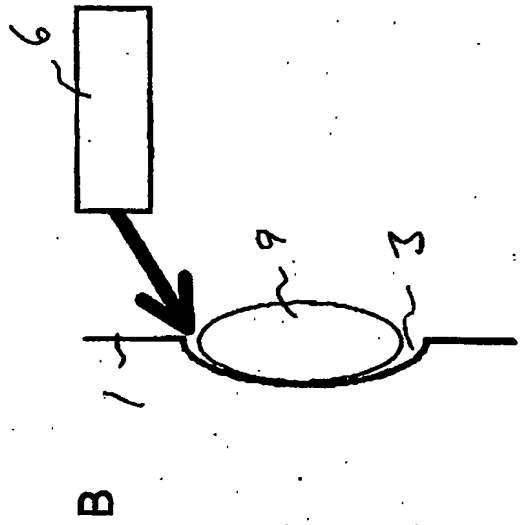


Fig. 5



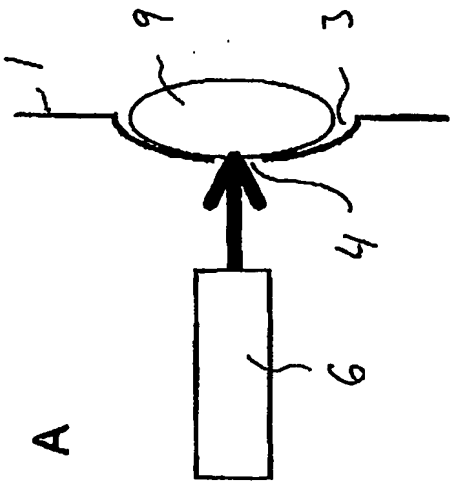


Fig. 6

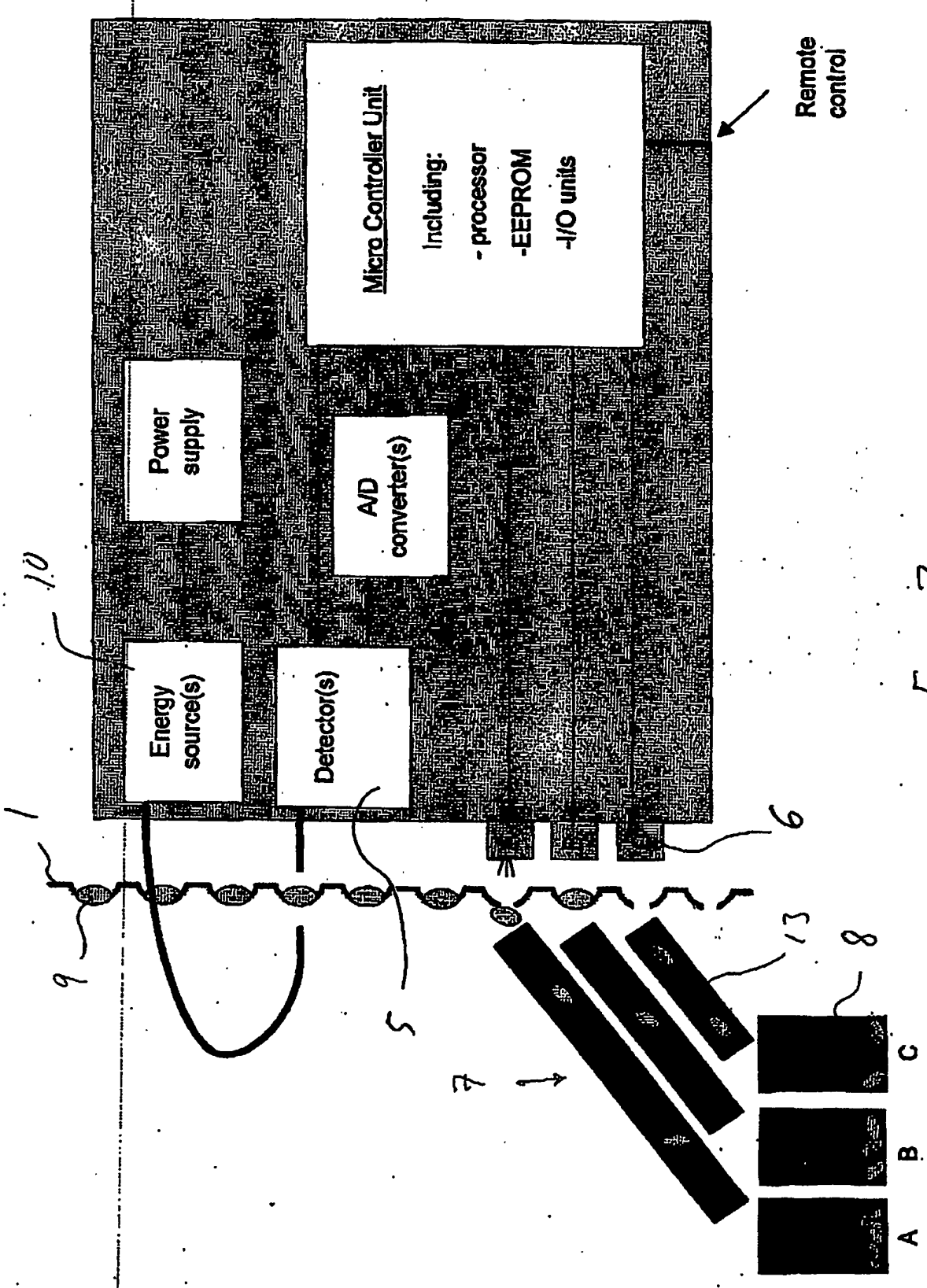


Fig. 7

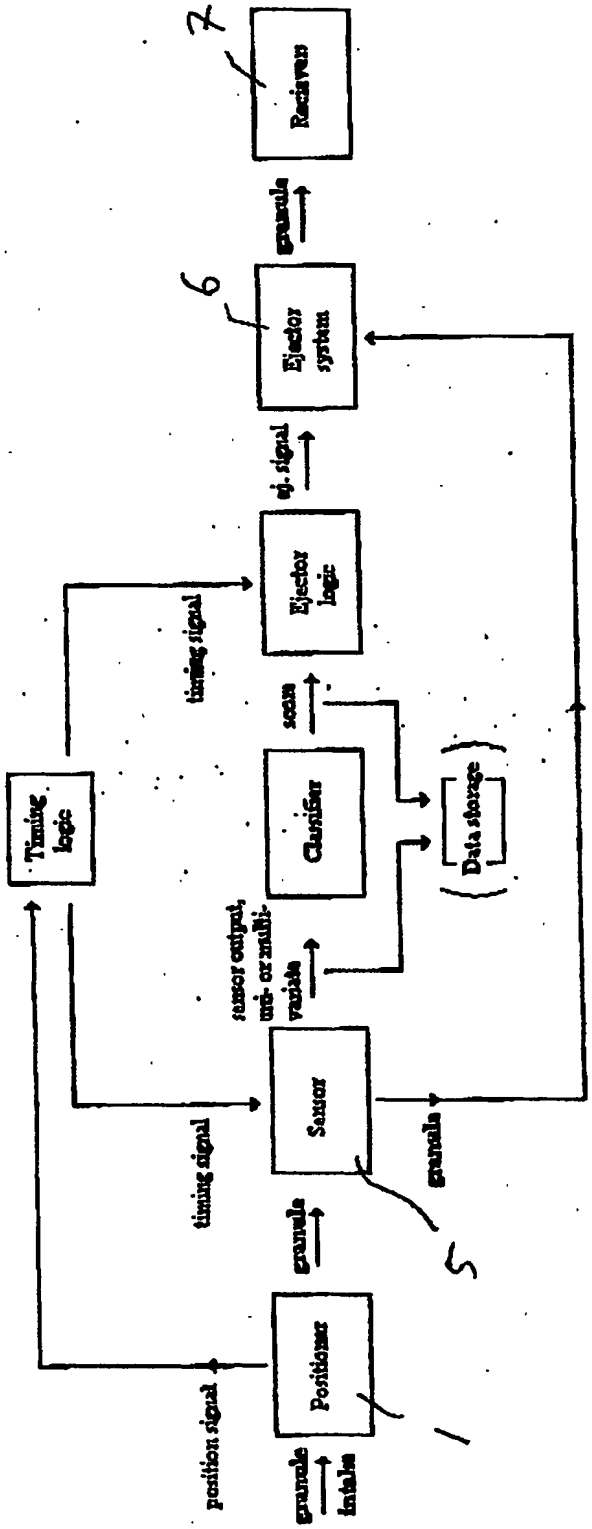


Fig. 8